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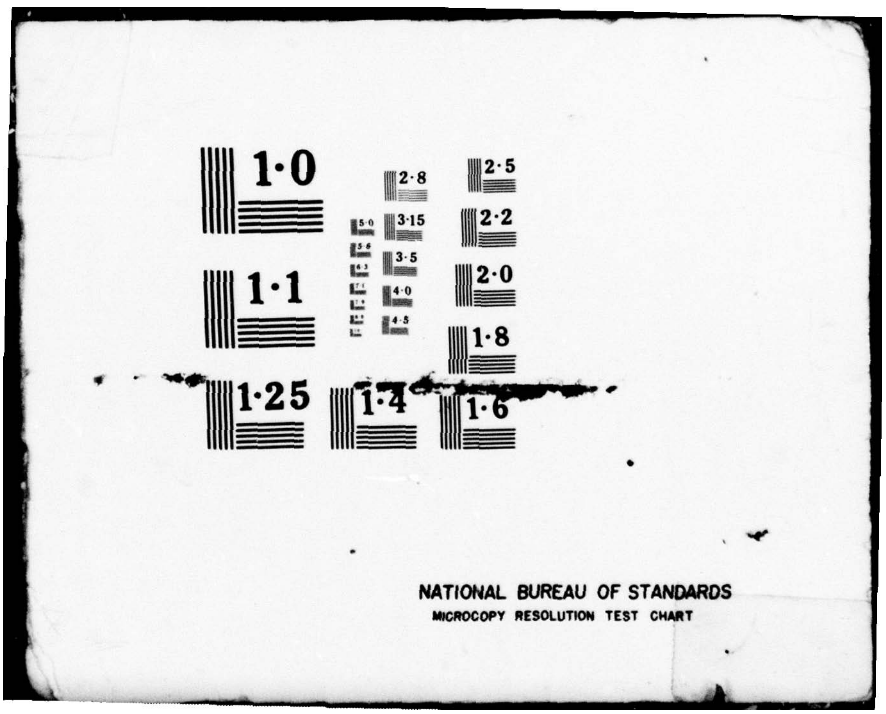
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REPORT NO. FAA-ASP-78-7

LEVEL II

AD A069818

ESTABLISHMENT CRITERIA FOR DISTANCE MEASUREMENT EQUIPMENT (DME) WITH INSTRUMENT LANDING SYSTEM AND/OR LOCALIZER APPROACH AIDS

December 1978

Prepared for:

U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
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16. Abstract

This report develops revised establishment criteria for Distance Measuring Equipment (DME) with either Instrument Landing System (ILS) or localizer approach aids. The criteria are based upon analysis of DME payoffs versus the cost of providing and maintaining the equipment. This benefit/cost analysis considers the following factors:

[redacted] Use of DME in lieu of ILS outer marker beacon;
Reduced probability of approach accidents;
Averted flight disruptions due to reduced localizer minima;
Averted missed approaches due to additional information provided;
Expedited aircraft departures due to reduced departure flight path length.

Former criteria concentrated on DME establishment for purposes of traffic expedition and approach minima reduction. Revised criteria consider, in addition to the foregoing, DME as a safety aid.

The revised criteria identify 281 ILS runways and 35 localizer runways for DME establishment. At an average per-site equipment and installation cost of $62,900, the potential program cost is approximately $20 million.

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EXECUTIVE SUMMARY

This report develops revised establishment criteria for single distance measuring equipment (DME) use with either instrument landing system (ILS) or localizer approach aids.

These criteria are based on a benefit/cost analysis that considers the following factors:

1. Use of DME in lieu of an outer marker when the siting of an outer marker is not feasible;

2. Reduced probability of approach accidents on localizer and/or ILS-equipped runways;

3. Averted flight disruptions due to reduced localizer minima;

4. Averted missed approaches due to additional information provided the pilot;

5. Expedited departures due to reduced departure flight path length.

Candidate pre-screening criteria were also developed for FAA Region use, based on AIA's. Benefit/cost criteria and an associated computer program, incorporating those criteria, were developed for FAA Headquarters use in screening those candidate runways for DME establishment identified by the regions.

The revised criteria identify up to 281 ILS runways and 35 localizer-only runways for DME establishment. At an average per-site equipment and installation cost of $62,900, the potential total program cost is approximately $20 million.

I. INTRODUCTION AND PURPOSE

Criteria for the establishment of terminal air navigation facilities and air traffic control services provided by the FAA are published in Airway Planning Standard Number One (APS-1) (Reference 1). These criteria are published to foster the planned development of a safe and efficient National Airspace System while at the same time guiding the allocation of resources for facilities and services.

The purpose of this report is to develop revised establishment criteria for distance measuring equipment (DME) when used as an approach aid in combination with either an instrument landing system (ILS) or a localizer (LOC) system. The new criteria are based on an analysis of the costs and benefits of DME's expressed in terms of annual instrument approaches (AIA) on the candidate runway.

According to APS-1, an airport is a candidate for the establishment of a facility or service when it meets the specified criteria and it is economically justified by a benefit/cost analysis. Recognizing the burden that would be placed on field facilities by requiring detailed benefit/cost analyses of potential candidates and their objections to such a procedure, DME establishment criteria based on typical or normalized costs will be used by regional personnel to identify potential DME candidates during preliminary budget formulation. Candidates thus identified will be screened and ranked by benefit/cost analysis in FAA Headquarters, using supporting data furnished by the regions and their responses to the annual Call for Estimates. Regional offices will have the option of using benefit/cost analyses to identify potential DME candidates.

II. PREVIOUS ILS ESTABLISHMENT CRITERIA

2.1 DME with ILS

Previous criteria for DME, as published in APS-1, were:

(a) A DME (single equipment) may be installed with an ILS in lieu of a marker beacon at locations where the geographical or operational environment is such that no final approach fix can be economically sited or transition to the ILS cannot be made using adjacent navigation aids, and procedures and operations will be simplified.1/

(b) An ILS airport recording 1,400 or more annual instrument approaches is a candidate for a DME facility when:

(1) Lower landing minima will be authorized in accordance with applicable agency instrument approach criteria; and

(2) A climatology study indicates that the DME will provide a significant reduction in the number of missed approaches, cancellations, or diversions; or

(3) The DME will expedite the flow of IFR air traffic arriving and departing the airport.

(c) ILS airports with between 700 and 1,399 annual instrument approaches may be considered for a DME facility when an individual location study indicates that the DME will result in a number of additional completed approaches that is commensurate with the cost of the facility.

(d) Discontinuance. Except where used in lieu of a marker beacon, a DME facility at an ILS with approach lights serving an airport recording less than 400 annual instrument approaches is a candidate for decommissioning.

1/ FAA Order 8260.19, "Flight Procedures and Airspace," par. 741d(3), states that DME will not be used as the sole means for identifying fixes or establishing transitions. When DME is the only means, specialists are instructed to program an outer compass locator or limit use of the ILS to DME-equipped aircraft only. Revised criteria, therefore, no longer allow DME establishment in lieu of a marker beacon for transition to the ILS.

III. REVISED ESTABLISHMENT CRITERIA FOR DME WHEN USED WITH ILS OR LOCALIZER SYSTEMS

The benefits provided by a DME depend on a number of factors--the feasibility of installing an outer marker with qualified ILS's; the reduction of minimums attributable to DME when used with localizer, including the localizer component of ILS; the distribution of IFR weather conditions at the airport; traffic levels (AIA's) on the proposed DME runway by user category (air carrier, air taxi, general aviation, and military); and hub size. A DME may qualify for establishment solely on the basis of its use in lieu of an outer marker with a qualified ILS. This establishment criterion is directly dependent on the difficulty, as measured by cost, of installing and maintaining the outer marker. The runway activity level, by user group, directly influences the magnitude of the DME-induced benefit and acts as a multiplier on the single event benefits which are, in turn, related to reduced minimums, local IFR weather characteristics, and average reduction in departure flight path distance, if applicable. All of these variables are utilized by FAA Headquarters in screening those runways that are candidates for DME establishment as identified by FAA regional offices. A subset of these variables is required by the FAA regions to identify acceptable candidate runways for DME establishment, in accordance with the procedure described below.

3.1 Candidate Runway Selection Criteria

A runway where DME may be used with ILS in lieu of an outer marker as described in Section 3.1.1, or which meets the annual instrument approach criteria of Section 3.1.2, is a candidate for DME establishment.

3.1.1 DME in Lieu of an Outer Marker

A runway is a candidate for DME implementation with an ILS when the prevailing geographical or operational environment is such that no final approach fix can be economically sited.

3.1.2 Traffic-Related Criteria

A runway is a candidate for DME establishment when the annual instrument approaches recorded for that runway meet or exceed any combination of conditions presented in Section 3.2.

3.1.3 Benefit/Cost Screening (Phase II Screening)

ILS and/or localizer runways identified by the FAA regions (Phase I screening), using the procedures described in Section 3.2 as candidates for DME establishment, will be assessed in FAA Headquarters (Phase II screening) using the benefit/cost technique described in this report. FAA regional offices shall submit data required for Phase II screening purposes (See Section 3.3) with their responses to the annual Call for Estimates.

3.2 Candidate Verification

The procedures for use by the FAA regions in screening potential candidate runways for DME establishment are described in paragraphs 3.2.1 and 3.2.2 for localizer and ILS (including localizer) equipped runways, respectively.

3.2.1 Localizer (No Glide Slope) Equipped Runways

To determine whether a localizer equipped runway is a candidate for DME establishment:

(a) Compute the number of AIA's on the candidate runway for each user category as follows:

(1) Determine the AIA's by an on-site survey; or

(2) Calculate the AIA's by estimating the percentage of total airport AIA's that occurred on the candidate runway. Table 3.1 may be used for this purpose.

(b) Determine the lowest approach minima for the largest category of aircraft (i.e., Approach Category A, B, C, or D) consistently using the runway.

(c) Estimate, using TERPS criteria (Reference 2), the least approach minimums that will be authorized for localizer/DME approaches on the candidate runway, for the aircraft category determined in (b).

(d) Determine hub size of candidate airport. Hub designations may be determined by computing the percent of annual national enplanements at the airport.

TABLE 3.1

Nominal Distribution of Airport Traffic (AIA's)
Among Available Instrumented Runways

Number of Instrumented Runways Available at Airport	Prioritized Distribution from Busiest (1) to Least Busy (N) Runway (Percent Airport Traffic on Designated Runway)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	100													
2	70	30												
3	60	28	12											
4	50	25	15	10										
5	40	23	15	12	10									
6	30	20	15	15	10	10								
7	30	20	15	12	10	8	5							
8	30	20	15	10	10	5	5	5						
9	28	17	15	10	10	5	5	5	5					
10	25	15	15	10	10	5	5	5	5	5				
11	23	15	10	10	10	7	5	5	5	5	5			
12	20	15	10	10	10	5	5	5	5	5	5	5		
13	20	15	10	10	7	5	5	5	5	5	5	5	3	
14	18	14	10	10	7	5	5	5	5	5	5	5	3	3

Reference: Expanded from data obtained from FAA ASP-220.

Percent of Total Annual National Enplanements at the Candidate Airport*	Hub Size
1.00	Large
0.25 to 0.99	Medium
0.05 to 0.24	Small
Less than 0.05	Non

(e) Determine qualifying AIA's. From Table 3.2, determine the qualifying AIA's for each user category (air carrier, air taxi, general aviation, and military) using the localizer and localizer/DME minima developed in steps (b) and (c), respectively. When these minima do not coincide with those values listed in Table 3.2, round off to the nearest Table 3.2 value. (Minima that lie half way between the ceiling and/or visibility values of Table 3.2 should be rounded off to the lower Table 3.2 value.)

If the minima values determined in steps (b) or (c) exceed the limits of Table 3.2 by more than 100 feet and/or 1/2 nautical mile, alternate criteria will be provided by the Office of Aviation System Plans.

(f) Determine the acceptability of the localizer runway as a candidate for DME establishment. Enter the recorded and qualifying AIA's for the selected runway as indicated below. The contribution of each user category toward satisfying the candidate runway acceptability criteria is determined by summation. A localizer runway with a total of 1.0 or greater meets the AIA criteria and is a candidate for DME establishment.

* Current value of annual national enplanements may be obtained from the Office of Aviation System Plans.

TABLE 3.2

Qualifying AIA's at Localizer Runways

User Group	Hub Size	Localizer Minima 400 1/2	400 1	500 1/2	500 1	600 1/2	600 1	600 1-1/2	700 1/2	700 1	700 1-1/4	700 1-1/2	700-2
LOC/DME Min = 300 1/2													
AC	Large	67	34	30	21	18	14	10	11	10	8	7	5
AC	Medium	92	46	41	29	24	19	14	15	13	12	10	7
AC	Small	116	58	51	36	30	24	18	19	17	15	13	9
AC	Non	156	78	69	48	41	33	24	26	22	20	17	12
AT	All	1,105	554	488	342	289	232	168	186	158	139	123	87
GA/Mil	All	5,845	2,931	2,580	1,812	1,527	1,227	888	983	838	736	652	460
LOC/DME Min = 300 1													
AC	Large		81		34		20	13		12	10	9	6
AC	Medium		111		46		27	18		17	14	12	8
AC	Small		139		58		34	22		21	18	16	11
AC	Non		188		79		45	30		28	24	21	14
AT	All		1,327		556		322	215		201	172	150	101
GA/Mil	All		7,020		2,940		1,702	1,137		1,062	911	793	537
LOC/DME Min = 400 1/2													
AC	Large		71	56	32	25	19	13	14	12	10	9	6
AC	Medium		98	77	44	34	26	17	20	16	14	12	8
AC	Small		123	96	55	43	32	22	25	20	18	15	10
AC	Non		166	130	74	58	44	30	33	28	24	21	14
AT	All		1,171	921	525	413	310	209	236	196	168	147	100
GA/Mil	All		6,197	4,874	2,775	2,185	1,642	1,107	1,250	1,035	891	777	528
LOC/DME Min = 400 1													
AC	Large				61		27	16		15	13	11	7
AC	Medium				83		37	22		21	17	15	10
AC	Small				104		46	28		26	22	18	12
AC	Non				141		63	38		35	29	25	16
AT	All				998		445	269		248	207	177	115
GA/Mil	All				5,281		2,352	1,421		1,310	1,096	936	609

NOTE: Localizer minima are ceiling and prevailing visibility associated with the Height Above Touchdown (HAT).

User Category

Air Carrier:	$\frac{\text{AIA's on Runway}}{\text{Qualifying AIA's}}$	=	x.xx
Air Taxi:	$\frac{\text{AIA's on Runway}}{\text{Qualifying AIA's}}$	=	x.xx
General Aviation:	$\frac{\text{AIA's on Runway}}{\text{Qualifying AIA's}}$	=	x.xx
Military:	$\frac{\text{AIA's on Runway}}{\text{Qualifying AIA's}}$	=	x.xx
	Total (Estimated Benefit/Cost Ratio)	=	x.xx

3.2.2 Instrument Landing System (ILS) Equipped Runways

Steps (a) through (d) are identical to steps (a) through (d) of Section 3.2.1 but are repeated in this section to provide a totally self-contained description of the DME candidate verification procedure.

To determine whether an ILS-equipped runway is a candidate for DME establishment:

(a) Compute the number of AIA's on the candidate runway for each user category as follows:

(1) Determine the AIA's by an on-site survey; or

(2) Calculate the AIA's by estimating the percentage of total airport AIA's that used the candidate runway. Table 3.1 may be used for this purpose.

(b) Determine the lowest approach minima for the largest category of aircraft (i.e., Approach Category A, B, C, or D) consistently using the runway.

(c) Estimate, using TERPS criteria (Reference 2), the least approach minimums that will be authorized for localizer/DME approaches on the candidate runway, for the aircraft category determined in (b).

(d) Determine hub size of candidate airport. Hub designations may be determined by computing the percent of annual national enplanements at the airport.

Percent of Total Annual National Enplanements at the Candidate Airport*	Hub Size
1.00	Large
0.25 to 0.99	Medium
0.05 to 0.24	Small
Less than 0.05	Non

(e) Determine qualifying AIA's. From Table 3.3, determine the qualifying AIA's for each user category (air carrier, air taxi, general aviation, and military) using the localizer and localizer/DME minima developed in steps (b) and (c), respectively. When these minima do not coincide with those values listed in Table 3.3, round off to the nearest Table 3.3 value. (Minima that lie half way between the ceiling and/or visibility values of Table 3.3 should be rounded off to the lower Table 3.3 value.)

If the minima values determined in steps (b) or (c) exceed the limits of Table 3.3 by more than 100 feet and/or 1/2 nautical mile, alternate criteria will be provided by the Office of Aviation System Plans.

(f) Determine the acceptability of the selected ILS runway as a candidate for DME establishment. Enter the recorded and qualifying AIA's for the selected runway as indicated below. The contribution of each user category toward satisfying the candidate runway acceptability criteria is determined by summation. An ILS runway with a total of 1.0 or greater meets the traffic level (AIA's) criteria and is a candidate for DME establishment.

*Current value of annual national enplanements may be obtained from the Office of Aviation System Plans.

TABLE 3.3

Qualifying AIA's at ILS-Equipped Runways

User Group	Hub Size	Localizer Minima 400 1/2	400 1	500 1/2	500 1	600 1/2	600 1	600 1-1/2	700 1/2	700 1	700 1-1/4	700 1-1/2	700 2
LOC/DME Min = 300 1/2													
AC	Large	190	190	190	190	190	190	190	190	190	190	190	190
AC	Medium	260	260	260	260	260	260	260	260	260	260	260	260
AC	Small	326	326	326	326	326	326	326	326	326	326	326	326
AC	Non	442	442	442	442	442	442	442	442	442	442	442	442
AT	All	7,126	5,055	4,684	3,718	3,292	2,794	2,160	2,347	2,059	1,846	1,665	1,224
GA/Mil	All	17,110	9,908	8,889	6,514	5,580	4,561	3,368	3,709	3,189	2,817	2,510	1,790
LOC/DME Min = 300 1													
AC	Large		190		190		190	190		190	190	190	190
AC	Medium		260		260		260	260		260	260	260	260
AC	Small		326		326		326	326		326	326	326	326
AC	Non		442		442		442	442		442	442	442	442
AT	All		7,655		5,065		3,559	2,634		2,495	2,205	1,966	1,404
GA/Mil	All		19,496		9,935		6,158	4,249		3,985	3,450	3,024	2,078
LOC/DME Min = 400 1/2													
AC	Large	190	190	190	190	190	190	190	190	190	190	190	190
AC	Medium	260	260	260	260	260	260	260	260	260	260	260	260
AC	Small	326	326	326	326	326	326	326	326	326	326	326	326
AC	Non	442	442	442	442	442	442	442	442	442	442	442	442
AT	All	12,118	7,297	6,586	4,896	4,217	3,468	2,580	2,835	2,445	2,165	1,932	1,384
GA/Mil	All	63,599	17,851	14,935	9,461	7,693	5,959	4,146	4,641	3,892	3,377	2,966	2,047
LOC/DME Min = 400 1													
AC	Large		190		190		190	190		190	190	190	190
AC	Medium		260		260		260	260		260	260	260	260
AC	Small		326		326		326	326		326	326	326	326
AC	Non		442		442		442	442		442	442	442	442
AT	All		12,118		6,826		4,421	3,122		2,937	2,559	2,255	1,568
GA/Mil	All		63,599		15,870		8,204	5,223		4,846	4,107	3,541	2,348

NOTE: Localizer minima are ceiling and prevailing visibility associated with the Height Above Touchdown (HAT).

User Category		
Air Carrier:	$\frac{\text{AIA's on Runway}}{\text{Qualifying AIA's}}$	= x.xx
Air Taxi:	$\frac{\text{AIA's on Runway}}{\text{Qualifying AIA's}}$	= x.xx
General Aviation:	$\frac{\text{AIA's on Runway}}{\text{Qualifying AIA's}}$	= x.xx
Military:	$\frac{\text{AIA's on Runway}}{\text{Qualifying AIA's}}$	= x.xx
	Total (Estimated Benefit/Cost Ratio)	= x.xx

3.3 Regional Data Submission

For those runways which qualify as candidates for DME establishment under Section 3.1 (DME in lieu of outer marker) or 3.2, the FAA regional office shall complete and submit the required data form (Table 3.4) in response to the Annual Call for Estimates.

3.4 Discontinuance Criteria

When the DME is used in lieu of an outer marker with an ILS, the criteria of Section 3.4.1 shall apply. For all other cases, the criteria of Section 3.4.2 shall apply.

3.4.1 When the DME is used in lieu of an outer marker with an ILS, it shall not be decommissioned. If the ILS is decommissioned, then the DME shall also be discontinued unless it is to be retained as part of a straight-in nonprecision approach facility.

3.4.2 A DME is a candidate for discontinuance when the total (estimated benefit/cost ratio) of Section 3.2.1 or 3.2.2 for localizer or ILS runways, respectively, becomes less than 0.6 (which is the ratio of 15-year present value annual DME O&M costs to 15-year present value total DME costs--see Section IV).

TABLE 3.4

DME with ILS or Localizer
Establishment Criteria Data Requirements

Check largest aircraft category that uses this runway:

- Aircraft Category A ☐
- Aircraft Category B ☐
- Aircraft Category C ☐
- Aircraft Category D ☐

Localizer and Localizer/DME Minima Associated with Aircraft Category Checked Above:

LOCALIZER APPROACH		LOCALIZER/DME APPROACH	
Ceiling	________ ft	Ceiling	________ ft
Visibility	________ nmi	Visibility	________ nmi

Weather Condition (Optional)*	% TOTAL OBSERVATIONS
(A) (1500 and/or 3) > C/V $\geq$ 400/1	________
(B) (400 and/or 1) > C/V $\geq$ 200 1/2.	________
(C) (200 and/or 1/2) > C/V $\geq$ 100 1/2.	________
(D) (100 and/or 1/4) > C/V.	________

Runway AIA's (by User Group)	AIA's
General Aviation	________
Air Taxi	________
Air Carrier.	________
Military	________
Hub Size (Large, Medium, Small, or Non)	________

Average Averted Missed Approach Go-Around Distance in nmi (nominally set at 40.05 nmi unless overridden by regional input) (by User Group)

	GO-AROUND DISTANCE
General Aviation	________ nmi
Air Taxi	________ nmi
Air Carrier.	________ nmi
Military	________ nmi

*National average weather may be used in lieu of airport-specific weather data if this information is not supplied.

TABLE 3.4

(Continued)

DME Cost Estimates

Equipment (Nominal Value $48,400) $

Installation (Nominal Value $14,500) . . . . $

Annual O&M (Nominal Value $13,721) . . . . $

NOTE: Nominal values are used unless overridden by regional input.

The following information is needed when the proposed DME is expected to expedite departures:

Estimated DME-Induced Reduction in Departure Flight Path Distance - Average per Departure (by User Group)

General Aviation ________ nmi

Air Taxi . . . . ________ nmi

Air Carrier. . . . . ________ nmi

Military . . . . ________

OR

Estimated DME-Induced Reduction in Departure Flight Time - Average per Departure (by User Group)

General Aviation . . . . ________ hrs

Air Taxi . . . . ________ hrs

Air Carrier. . . . . ________ hrs

Military . . . . ________ hrs

The following information is needed when the proposed DME is to be used with ILS in lieu of an outer marker:

ILS 15-Year Discounted Cost Excluding Outer Marker Beacon Cost (from ASP-220) . . . . $________

Outer Marker Beacon 15-Year Discounted Cost (from ASP-220. For alternative, see discussion on DME in lieu of outer marker example computation). $________

ILS 15-Year Discounted Benefit by User Category (from ASP-220):

Air Carrier. . . . . $________

Air Taxi . . . . $________

General Aviation . . . . $________

Military . . . . $________

3.5 Example of FAA Region (Phase I) Candidate Verification Computations

Runway 24 at Palomar Airport, Carlsbad, California, and Runway 07 at Herndon Airport, Orlando, Florida, were selected to illustrate the DME establishment candidate verification procedures for localizer and ILS-equipped runways, respectively. The steps identified in Sections 3.5.1 and 3.5.2 correspond exactly to the steps described in Sections 3.2.1 and 3.2.2, respectively.

3.5.1 Localizer (No Glide Slope) Equipped Runway Example

Runway 24, Palomar Airport, Carlsbad, California

(a) Determine runway AIA's by user category. All airport AIA's occur on the single IFR runway resulting in the following:

User Category	Runway AIA's
Air Carrier	11
Air Taxi	30
General Aviation	2,530
Military	37

(b) Determine published minimums for localizer approaches for the largest aircraft category consistently using the runway:

Aircraft Category	Associated User Category	Localizer Approach Minima Ceiling (feet)	Localizer Approach Minima Visibility (nmi)
D	Air Carrier	737	2

(c) Estimate approach minimums that will be authorized for localizer/DME approaches on the candidate runway for the chosen aircraft category:

(d) **Establish airport hub size.**

Since Palomar has less than 0.05 percent of the total annual national deplanements, it is classified as a non-hub airport.

(e) **From Table 3.2 determine the qualifying AIA's for each user category.**

	Localizer Ceiling/ Visibility Minima		Localizer/DME Ceiling/ Visibility Minima		
User Category	From Step B	Adjusted for Table 3.2 Compatibility	From Step C	Adjusted for Table 3.2 Compatibility	Qualifying AIA's
Air Carrier Non-Hub	737 2	700 2	400 3/4	400 1/2	14
Air Taxi					100
General Aviation					528
Military					528

(f) **Verify validity of runway candidacy. Use recorded AIA's from Step (a) and qualifying AIA's from Step (e).**

User Category	Recorded AIA's	Qualifying AIA's
Air Carrier	11	14
Air Taxi	30	100
General Aviation	2,530	528
Military	37	528

Air Carrier: $\frac{11}{14} = .79$

Air Taxi: $\frac{30}{100} = .30$

General Aviation: $\frac{2,530}{528} = 4.79$

Military: $\frac{37}{528} = .07$

Total Ratio Value = 5.95

Since the approximated benefit/cost ratio is equal to or greater than 1.0, i.e., 5.95, Runway 24 at Palomar Airport would be considered as a valid candidate for DME establishment.

3.5.2 Instrument Landing System (ILS) Equipped Runway Example

Runway 07, Herndon Airport, Orlando, Florida

(a) Determine runway AIA's by user category. Runway 07 was ranked first in traffic of the four instrumented runways at Herndon. From Table 3.1, it is estimated that Runway 07 receives 50 percent of Herndon's AIA's resulting in the following traffic levels by user category.

User Category	Runway AIA's
Air Carrier	1
Air Taxi	19
General Aviation	882
Military	32

(b) Determine the published minimums for localizer (not ILS) approaches on the candidate runway, for the largest aircraft category consistently using the runway.

Aircraft Category	Associated User Category	Localizer Approach Minima Ceiling (feet)	Localizer Approach Minima Visibility (nmi)
C	Air Taxi	491	1/2

(c) Estimate approach minimums that will be authorized for localizer/DME approaches on the candidate runway, for the chosen aircraft category:

Aircraft Category	Associated User Category	Localizer Approach Minima Ceiling (feet)	Localizer Approach Minima Visibility (NMI)
C	Air Taxi	300	1/2

(d) **Establish airport hub size.**

Since Herndon has less than 0.05 percent of the total annual national enplanements, it is classified as a non-hub airport.

(e) From Table 3.3 determine the qualifying AIA's for each user category.

	Localizer Ceiling/ Visibility Minima		Localizer/DME Ceiling/ Visibility Minima		
User Category	From Step B	Adjusted for Table 3.3 Compatibility	From Step C	Adjusted for Table 3.3 Compatibility	Qualifying AIA's
Air Carrier Non-Hub					442
Air Taxi	491 1/2	500 1/2	300 1/2	300 1/2	4,684
General Aviation					8,889
Military					8,889

(f) Verify validity of runway candidacy.

Use recorded and qualifying AIA's, by user category from Steps (a) and (e), respectively.

Air Carrier: $\frac{1}{442} = .0023$

Air Taxi: $\frac{19}{4,684} = .0041$

General Aviation: $\frac{882}{8,889} = .0992$

Military: $\frac{32}{8,889} = .0036$

Total Ratio Value = .1092

Since the approximated benefit/cost ratio is less than 1.0, i.e., 0.1092, Runway 07 at Herndon Airport would not be considered as a valid candidate for DME establishment.

IV. TYPICAL SINGLE DME COSTS

Typical implementation and annual recurring costs (in 1977 dollars) for single unit distance measuring equipment are listed below. Also shown is the resulting 15-year discounted (10 percent) present value. Equipment costs include electronic equipment and freight. Installation costs include all other elements required to bring the DME up to an operational state, such as engineering, construction, electronic installation, and initial flight inspection.

	Cost (1977 $)	15-Year Discounted Present Value Factor	Present Value (1977 $)
Investment[(a)]			
Equipment	$ 48,400		
Installation	14,500		
Total Investment	$ 62,900	1.0	$ 62,900
Annual O&M[(b)]	$ 13,721	7.605	$104,348
Total 15-Year Cost	$268,715		
Total 15-Year Discounted Present Value			$167,248

All benefit/cost analyses described in this document utilize a 15-year discounted present value DME cost equal to $167,248.

Source: (a) AAF-130
(b) AAF-250

V. DME-INDUCED BENEFITS

Based on a review of previously-used DME establishment criteria obtained from Airway Planning Standard Number One and the FY 1977 Call for Estimates, IFR-rated pilot interviews and discussions with FAA personnel both at Headquarters and in the regions, a list of candidate benefits was established. These benefits were divided into four categories to assist in assessing the desirability of incorporation into the DME establishment criteria. These DME benefit categories are: (1) those resulting from a reduction of the published ceiling and visibility approach minima; (2) those resulting from providing the pilot additional information but not affecting the published ceiling and visibility approach minima; (3) those made possible by additional operating flexibility; and (4) improved safety in the form of reduced approach accident rates.

Candidate benefits were developed in each category, recognizing that those benefits which reduced approach minimums would be relatively easy to quantify. Conversely, those DME benefits derived from providing the pilot additional information would be most difficult to quantify, somewhat subjective, and therefore possibly difficult to defend (particularly if they were a major contributor to the establishment criteria).

The initial list of candidate benefits, shown in Table 5.1, were screened with respect to potential benefit contribution, applicability to most runways, and the feasibility of developing acceptable quantification procedures.

With the concurrence of ASP-220, the following benefit categories were selected for inclusion in the DME establishment criteria:

- DME in lieu of an outer marker
- improved safety
- reduced localizer minima
- averted missed approach
- expedited departure

The following sections describe the approach developed to quantify each of these five benefits.

TABLE 5.1

Candidate DME-Induced Benefits

Application	Reduction in Published Minima	Additional Pilot Information	Additional Operating Flexibility	Improved Safety
DME USE WITH ILS	. DME Use in Lieu of an Outer Marker* . Missed Approach Guidance Capability	. Averted Missed Approach*	. Expedited Departures* . Facilitate Noise Abatement . Procedures . Improved ATC Traffic Management . Improved Approach Reliability	. Reduced Approach Accident Rates*
DME USE WITH LOCALIZER OR LOCALIZER PORTION OF ILS	. Reduced Localizer Minima*	. Averted Missed Approach*	. Expedited Departures* . Facilitate Noise Abatement Procedures . Improved ATC Traffic Management . Improved Approach Reliability	. Reduced Approach Accident Rates*

* Retained for quantification and possible inclusion in final DME establishment criteria

5.1 DME Use in Lieu of an Outer Marker

In this application, the DME substitutes for the otherwise required outer marker beacon component of the ILS. This occurs when it is not technically and/or economically feasible to site and operate an outer marker. Thus, the benefits are based on the benefits associated with the establishment of an ILS on that runway. This potential ILS benefit must, however, be reduced to account for the fact that not all ILS-equipped aircraft are also equipped with DME; thus, only a subset of ILS aircraft can utilize this type of approach facility.

The method to quantify the 15-year discounted benefit/cost ratio involves combining the individual ILS and DME benefits/costs into a single ILS + DME benefit/cost as shown below:

$$\text{(ILS + DME) 15 Yr B/C} = \frac{\sum_{\substack{\text{User}\\\text{Group}}} \text{(ILS Benefit x AMFA + DME Benefit)}}{\text{(ILS - Outer Marker Cost) + DME Cost}}$$

where:

- All costs and benefits are 15-year discounted costs.
- All ILS benefits and costs are obtained from ASP-220 based on ILS establishment criteria (Reference 4).
- AMFA (avionics mix factor adjustor) listed in Table 5.3 is the ratio of ILS/DME avionics mix factor to ILS + ILS/DME avionics mix factor obtained from Table 5.2.

TABLE 5.2

Avionics Mix Factor
Percent of IFR (Localizer + ILS w/wo DME) Equipped Fleet
Function of Available Approach Aid and User Group

User Group	DME Installed at Runway	Runway Approach Aid Availability: Localizer Only, Percent Utilizing: Localizer	Localizer Only, Percent Utilizing: Localizer/DME	ILS, Percent Utilizing: Localizer	ILS, Percent Utilizing: Localizer/DME	ILS, Percent Utilizing: ILS	ILS, Percent Utilizing: ILS/DME
General Aviation	Yes	74.29	25.71	46.18	6.42	28.10	19.30*
	No	100.00	---	52.60	---	47.40	---
Air Taxi	Yes	44.26	55.75	13.11	3.56	31.14	52.19*
	No	100.00	---	16.67	---	83.33	---
Air Carrier	Yes	0.00	100.00	0.00	0.00	0.00	100.00*
	No	100.00	---	0.00	---	100.00	---
Military	Yes	44.26	55.75	13.11	3.56	31.14	52.19*
	No	100.00	---	16.67	---	83.33	---

Percents to be utilized in reduced localizer minima and averted missed approach benefit computations at non-ILS runways and expedited departure benefits

Percents to be utilized in reduced localizer minima and averted missed approach benefit computations at ILS runways

Percents to be utilized in DME in lieu of outer marker computations at ILS

* Percents to be utilized in computing safety benefits

TABLE 5.3

Avionics Mix Factor Adjustor

User Category	AMFA
General Aviation	0.407
Air Taxi	0.626
Air Carrier	1.000
Military	0.626

The (ILS + DME) 15-year benefit/cost is determined for each user category using the ILS benefit and AMFA identified for each category. The results are then summed over all user categories.

5.2 Improved Safety

This benefit is predicated on the assumption that the additional information provided by the DME will periodically prevent an approach accident that would have otherwise occurred.

Since it was not possible to establish when a pilot utilized his DME on approach, it was necessary to use "opportunity to use DME on an instrument approach (AIA)" as the basis of the safety analysis. It was assumed that pilot habit patterns, within a given user category, in terms of DME use per AIA opportunity, would not markedly change in time.

The total number of Annual Instrument Approaches (AIA's) by type of approach (i.e., LOC, LOC/DME, ILS, ILS/DME) was determined for each year between 1968 and 1975 inclusive. This was accomplished by first applying the 1976 mix of approaches by facility type to the earlier years and adjusting the results to account for the commissioning dates of the equipment and the overall trend in total instrument approaches. Then an avionics mix for each user group was determined by interpolating between information available in 1961 (AOPA survey) and 1976 (provided by FAA/ASP). Applying the avionics mix factors to the approaches by runway equipment gave the resulting AIA's by year and user group.

The number of approach accidents that occurred on ILS, ILS/DME, localizer, and/or localizer/DME runways during the eight years 1968-1975 was obtained from the NTSB Aircraft Accident Data Tapes. For the years 1974 and 1975, the avionics available on the aircraft (localizer, ILS, with/without DME) was determined by examining the individual FAA aircraft records by N number. These records were not available for the years 1968-1973. For those years, the avionics equipment on board aircraft involved in approach accidents was estimated by applying the avionics mix factor for the particular user category and year.

These accident and opportunity statistics were combined to produce accident rates for localizer as well as ILS opportunities, both with and without DME for each user category. The difference between the with and without DME rates produced "maximum likelihood" DME-induced accident rates.

These accident data were then subjected to statistical significance analysis. Only the DME/ILS air taxi and general aviation and air carrier equipment/user categories satisfied this test. The resulting maximum likelihood accident rate reduction was then adjusted to yield the 50 percent confidence bound.

The 50 percent confidence bound value of DME-induced accident rate reduction for the combined air taxi and general aviation user categories was equal to 1.763 accidents eliminated per one million instrument approaches. The value for air carrier users was 6.132 accidents eliminated per one million approaches. This value was incorporated into the DME safety benefit analysis for those user groups when operating at ILS runways. All other user categories at ILS and all user categories at localizer were nulled out of the DME safety benefits due to lack of sufficient supportive statistics. These results are summarized in Table 5.4.

TABLE 5.4

DME-Induced Accident Rate Reductions (ARR)
(per Million AIA's)

User Category	DME with ILS	Localizer
Air Carrier	6.132	NA
Air Taxi	1.763	NA
General Aviation	1.763	NA
Military	NA	NA

The safety benefit on ILS-equipped runways attributable to the establishment of DME may now be derived:

$$SB = AIA \times ARR \times AMF \times PVF \times ACPA$$

where:

SB = The DME-induced safety benefit discounted over 15 years

AIA = The recorded number of annual instrument approaches on the runway of interest

ARR = DME-induced accident rate reductions

AMF [(a)] = Avionics mix factor

PVF [(b)] = Present value factor incorporating projected activity over 15 years with 10% discount

ACPA [(c)] = Average cost per accident

Source: (a) Table 5.2; (b) Table 5.5; (c) Table 5.6 (GA and AT) and Table 5.7 (AC)

TABLE 5.5

Net Discount Factors for Benefit Estimation

Funding	10% Discount Factor	IFR Growth Factors AC	IFR Growth Factors AT	IFR Growth Factors GA	Net Discount Factors AC	Net Discount Factors AT	Net Discount Factors GA
1	.909	1.04	1.07	1.135	.945	.973	1.032
2	.826	1.08	1.14	1.270	.892	.942	1.049
3	.751	1.12	1.21	1.405	.841	.909	1.055
4	.683	1.16	1.28	1.540	.792	.874	1.052
5	.621	1.20	1.35	1.675	.745	.838	1.040
6	.564	1.24	1.42	1.810	.699	.801	1.021
7	.513	1.28	1.49	1.945	.657	.764	.998
8	.467	1.32	1.56	2.080	.616	.729	.971
9	.424	1.36	1.63	2.215	.577	.691	.939
10	.386	1.40	1.70	2.350	.540	.656	.907
11	.351	1.44	1.77	2.485	.504	.620	.870
12	.319	1.48	1.84	2.620	.472	.587	.836
13	.290	1.52	1.91	2.755	.441	.554	.799
14	.263	1.56	1.98	2.890	.410	.521	.760
15	.239	1.60	2.05	3.025	.382	.490	.723
	7.605				9.513	10.949	14.052

Military assumed equal to no-growth 15-year discount factor of 7.605

TABLE 5.6

Landing Accident Cost
($000)

Aircraft Type	% Fleet	Fatalities	Serious Injury	Minor Injury	Aircraft	Investigation*	Total
4W	3.6	$6,480	$1,005	$95	$30,000	$2,000	$39,580
3W	7.6	4,290	665	60	20,000	2,000	27,015
4N	23.2	3,000	465	45	8,800	2,000	14,310
3N	29.5	2,490	385	35	6,000	1,000	9,910
2N	19.8	2,160	340	30	4,000	1,000	7,530
Turboprop	10.4	1,620	250	25	1,200	1,000	4,095
Piston	5.4	810	125	10	1,200	1,000	3,145
Helicopter	0.4	390	65	5	600	500	1,560
Air Carrier Average	100.0	2,631	409	42	7,400	1,342	11,824
Air Taxi	100.0	600	60	10	200	500	1,370
General Aviation	100.0	270	25	5	50	200	550

*Estimated

Source: FAA Report ASP-78-1, "Establishment Criteria for Category I MLS" (Draft)

TABLE 5.7

Air Carrier Accident Costs and Benefits by Hub Size

Hub Size	Ratio to Average	Estimated Accident Cost	Benefit/AIA
Large	1.2773	15.103×10^6	$881.014
Medium	.9326	11.027×10^6	643.246
Small	.7435	8.791×10^6	512.812
Non	.5491	6.493×10^6	378.761
Average	1.0000	11.824×10^6	689.738

The resulting DME-induced safety benefit for general aviation is as follows:

$$SB_{GA\ @\ ILS} = AIA_{GA} \times (1.763 \times 10^{-6}) \times 0.1930 \times 14.052 \times 0.55 \times 10^6$$

$$SB_{GA\ @\ ILS} = AIA_{GA} \times \$2.630$$

The resulting DME-induced safety benefit for air taxi operations is as follows:

$$SB_{AT\ @\ ILS} = AIA_{AT} \times (1.763 \times 10^{-6}) \times 0.5219 \times 10.949 \times 1.37 \times 10^6$$

$$SB_{AT\ @\ ILS} = AIA_{AT} \times \$13.802$$

The resulting DME-induced safety benefit for air carriers is as follows:

$$SB_{AC\ @\ ILS} = AIA_{AC} \times (6.132 \times 10^{-6}) \times 1.00 \times 9.513 \times 11.824 \times 10^{6}$$

$$SB_{AC\ @\ ILS} = AIA_{AC} \times \$689.738$$

The air carrier safety benefit is an average over all four hub categories. In order to properly distribute the benefit among the various hub sizes, this average was adjusted with the same technique used in FAA Report No. ASP-75-1, "Establishment Criteria for Category I Instrument Landing System (ILS)," Appendix B. This technique essentially uses the distribution of benefits per averted flight disruption by hub size for air carriers to weight the average safety benefit. Table 5.7 lists the estimated safety benefits per AIA for air carriers by hub size.

Accident cost by user category and number of injuries per landing accident by generic aircraft type data are presented in Tables 5.8 and 5.9, respectively, which supplement the landing accident cost estimates of Table 5.6. All of this information has been extracted from other FAA publications.

5.3 Reduced Localizer Minima

When published (either estimated or actual) DME with localizer minima are lower than the published localizer minima (typically due to the ability to provide a step down fix past an obstruction), then some previously (without DME) disrupted flights will be averted. The product of 15-year discounted cost per annual averted flight disruption and the number of averted flight disruptions in the base year is equivalent to the 15-year discounted reduced localizer minima benefit.

The number of base-year averted flight disruptions is sensitive to the number of AIA's, the avionics mix factor, the localizer minima, the localizer/DME minima, and the weather characteristics. The interactions of the last three parameters are illustrated in Figure 5.1. In this example, the percent of IFR weather when the runway is open increased from WOBA to WOBA + WOBB (See Figure 5.1). The increase in "usable" IFR weather is:

$$IFRW = 1 + \left[\frac{WOBB-WOBA}{WOBA}\right]$$

TABLE 5.8

Accident Cost by User Category

Baseline Data	
Serious Injury	$ 45,000
Minor Injury	6,000
Passenger Death	300,000

Air Carrier		Aircraft	Avg. Cost (10^6)[a]	Number	%
Turbojet	4 Eng.	Widebody	30.0	96	3.6
	3 Eng.	Widebody	20.0	204	7.6
	4 Eng.	Narrow	8.8	623	23.2
	3 Eng.	Narrow	6.0	790	29.5
	2 Eng.	Narrow	4.0	531	19.8
Turboprop			1.2	280	10.4
Piston			1.2	145	5.4
Helicopter			.6	12	0.4
				2,681	

Average Air Carrier Aircraft Cost: $\$7.4 \times 10^6$

Average Air Taxi Aircraft Cost:[a] $.2 \times 10^6$

Average General Aviation Aircraft Cost:[a] $.05 \times 10^6$

Source: a. "Establishment Criteria for Category I MLS," Draft Report FAA-ASP-78-1, 8/78, Table A-5

TABLE 5.9

Number of Injuries per Landing Aircraft
by Generic Aircraft Type

Certificated-Route Air Carrier	Average Revenue Passenger	Fatalities	Serious Injury	Minor Injury
4W	166.5	21.6	22.3	15.7
3W	110.7	14.3	14.8	10.4
4N	77.0	10.0	10.3	7.2
3N	63.7	8.3	8.5	6.0
2N	55.6	7.2	7.5	5.2
Turboprop	41.6	5.4	5.6	3.9
Piston	20.8	2.7	2.8	2.0
Helicopter	10.4	1.3	1.4	1.0
Air Taxi	8.0	2.0	1.3	2.0
General Aviation	2.1	0.9	0.6	0.9

Source: FAA Draft Report ASP-78-1, "Establishment Criteria for Category I MLS"

The resulting reduced localizer minima benefit is computed as follows for each user group:

$$RLMB = AIA \times IFRW \times AMF \times BPAFD$$

where:

RLMB = reduced localizer minima 15 years discounted benefit for specified user group

AIA = annual instrument approaches to candidate runway

IFRW = increase in acceptable IFR weather factor applied to before DME conditions (derivation of this parameter is illustrated in Section 7.3)

AMF = avionics mix factor from Table 5.2

BPAFD = 15-year discounted benefit per annual averted flight disruption from Table 5.10

TABLE 5.10

Benefit per Annual Averted Flight Disruption

User Group	Hub Size	15-Year Discounted Benefit
Air Carrier	Large	$42,692
	Medium	31,173
	Small	24,851
	Non-Hub	18,355
	Average	33,425
Air Taxi	All	3,964
General Aviation	All	1,468
Military*	All	795

*Assumed no activity growth

Source: Computations based on Appendix B of Reference 6, MLS Report, using aircraft operating costs shown in Table 5.11

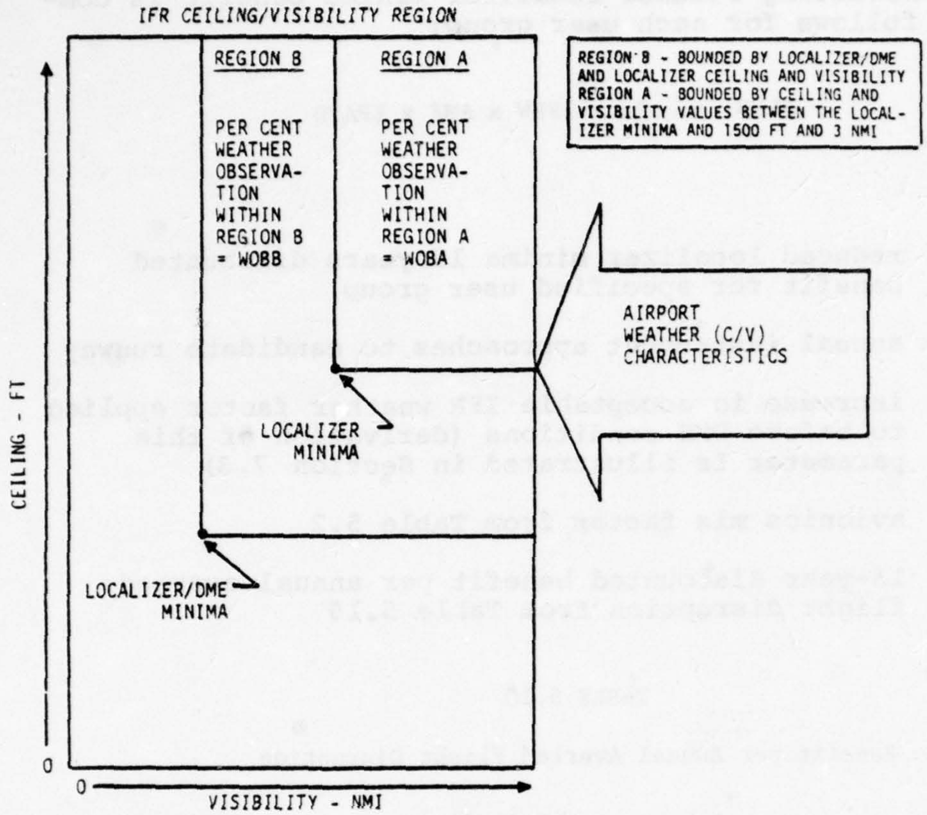

Figure 5.1 Reduced Localizer Minima (Minima/ Weather Interaction)

5.4 Averted Missed Approach

This benefit is predicated on the fact that additional information provided by the DME, not required for a localizer approach, may be used by the pilot to reduce the number of missed approaches that would have occurred without that information. Thus, this benefit occurs only when the prevailing IFR weather minima lie above the localizer minima as shown in Figure 5.2.

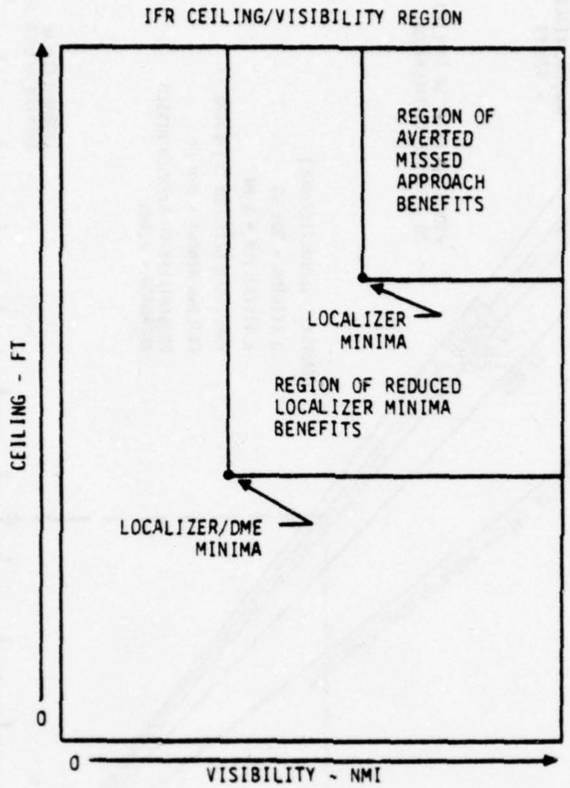

Figure 5.2 Regions of Reduced Localizer Minima and Averted Missed Approach Benefits

The approximation of reduced missed approach potential attributable to the addition of DME capability to either localizer or ILS approaches is displayed in Figure 5.3 and is sensitive to the prevailing Δ visibility and Δ ceiling, the published ceiling minima, and whether the DME is combined with localizer or ILS (where the Δ visibility and Δ ceiling is the difference between the prevailing weather and the published localizer/DME or ILS/DME minima as appropriate).

The approach used to develop Figure 5.3 was to establish a maximum value for the probability of averting a missed approach. This value corresponds to Δ ceiling, Δ visibility = 0, 0 and a published localizer/DME or ILS/DME (as appropriate) ceiling minima >1,000 feet and was set at 0.10 and 0.01 for localizer and ILS approaches, respectively (subsequently adjusted to 0.108 and 0.0108 to accommodate Δ ceilings and Δ visibilities greater than 1,250 feet and 2 nmi).

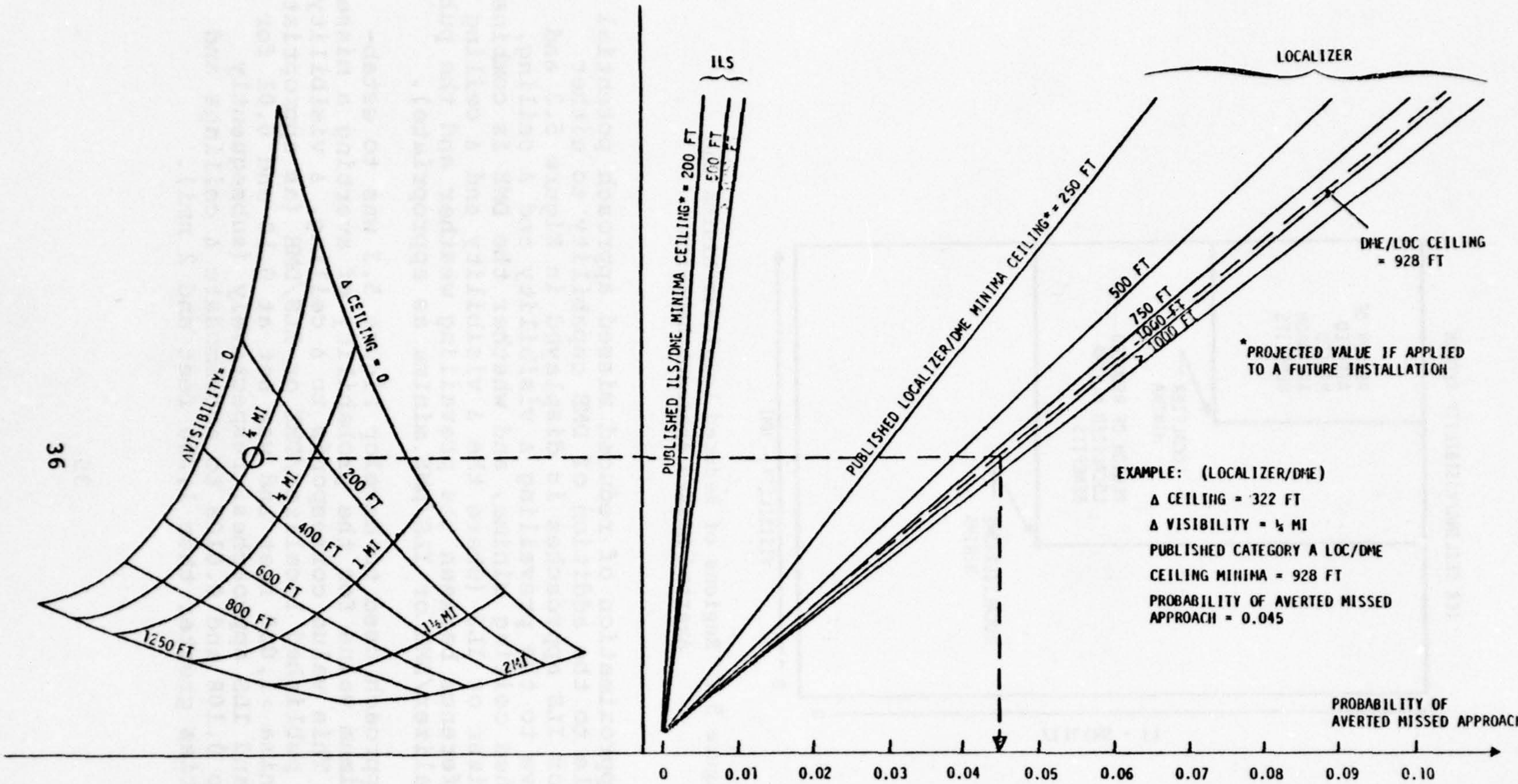

Figure 5.3 Probability of Averted Missed Approach Due to DME Opportunity

Reductions from the maximum probability values with increasing Δ ceiling and Δ visibility as well as reduced published ceiling minima were derived subjectively, based on achieving maximum sensitivity when close to low Δ ceiling and Δ visibility values, i.e., weather close to the published minimums.

The resulting probability of averted missed approach (PAMA) (obtained by using weighted values of that airport's weather conditions as described in Section 7.4) per AIA is then used to compute the averted missed approach benefit as follows:

$$AMAB = \sum_{\substack{\text{User} \\ \text{Groups}}} (PAMA) \times \frac{GAD}{40.05} \times AMF \times PVF \times BPAMA \times AIA$$

where:

PAMA = probability of an averted missed approach

GAD = missed approach go-around distance in nautical miles

AMF = avionics mix factor (aircraft equipped with DME) taken from Table 5.2

PVF = 15-year discount factor for appropriate user group taken from Table 5.5

BPAMA = dollar benefit for averted missed approach taken from Table 5.11

AIA = annual instrument approaches by user group

The relative magnitude of this benefit was small to the extent that the benefits associated with averted missed approaches under ILS/DME were dropped from the establishment and benefit/cost criteria.

TABLE 5.11

Average Benefit of an Averted Missed Approach

User Group	Average Go-Around Distance (nmi)	Average[a] Go-Around Speed (knots)	Average Go-Around Time (hours)	Average[b] Operating Cost ($/hour)	Average Benefit per Averted Missed Approach ($)
AC	40.05	200	0.20025	970	194.24
AT	40.05	140	0.2861	360	103.00
GA	40.05	110	0.3641	90	32.77
Mil	40.05	110	0.3641	90	32.77

Source: (a) FAA/Flight Standards
(b) ASP-220

5.5 Expedited Departure

This benefit results when the average departure flight path length is shortened by use of the proposed DME. This average reduction in route length must be determined by the region and is applied only to aircraft that are equipped with DME. If no reduced departure route length is submitted by the region, this value will be set at zero and no benefit will result.

The resulting benefit relationship is shown below:

$$EDB = \sum_{\substack{\text{User} \\ \text{Group}}} AIA \times \Delta DFPL \times EDF$$

where:

EDB	=	expedited departure benefit
AIA	=	annual instrument approaches by user group
ΔDFPL	=	reduction of departure flight path length, nmi, by user group
EDF	=	expedited departure factor by user group from Table 5.12. This factor includes avionics mix factor, operating costs, and 15-year discount factor. Derivation of this factor is provided in Section 7.5.

TABLE 5.12

Expedited Departure Benefits

User Group	Benefit/AIA/nmi Flight Path Reduction
Air Carrier	46.13
Air Taxi	15.70
General Aviation	2.95
Military	3.46

VI. CRITERIA IMPACT ASSESSMENT

Benefit-cost DME criteria were compared with Phase I numeric criteria to be published in Airway Planning Standard Number One. Criteria were applied to 535 runways having either a commissioned or planned full ILS and 181 commissioned or planned localizer/marker runways. The results, appearing in Table 6.1, document the "false alarm" rate (locations which pass Phase I but fail the Phase II benefit/cost criteria with benefit/cost ratios less than 1.0) and the "non-identification" rate (locations which meet Phase I but fail Phase II criteria). In all, there were 281 qualifiers for DME at ILS and 35 qualifiers for DME at localizer-only runways using Phase II criteria.

TABLE 6.1

DME Criteria Assessment

	Number of Runways Examined	Phase II Qualifiers (B/C ≥ 1.0)	False Alarms (Phase I ≥ 1.0, B/C < 1.0)	Non-Identification (Phase I < 1.0, B/C ≥ 1.0)
DME at ILS	535	281	2	7
DME at Localizer	181	35	25	3

Previous Airway Planning Standard criteria specified that an ILS airport recording 1,400 or more annual instrument approaches was a candidate for DME when lower localizer minima were authorized, fewer flight disruptions were anticipated, and IFR air traffic would be expedited.

In FY 1977, there were 282 airports having more than 1,400 AIA's. Of these, 12 airports did not have a full ILS while 15 already had DME installed. Using the previous Airway Planning Standard activity criteria, it was determined that up to 255 airports could qualify for DME, assuming compliance with the non-activity portions of the Planning Standard. Not included in this estimate are additional DME's that

were eligible for installation at airports having between 700 and 1,399 AIA's with special justification. However, based upon previous versus revised AIA activity criteria, it is concluded that the economic-based criteria are consistent with former numeric standards.

Airway Planning Standard Number One did not contain criteria for DME with localizer runway (other than in lieu of marker beacon). Thus, no comparison can be made with revised economic-based standards. The benefit/cost approach did, however, select 35 possible runways for localizer/DME as compared to 5 localizers now collocated with a DME.

VII. COMPUTATION OF DME BENEFIT/COST CRITERIA

The computations used to derive each of the five DME benefits, i.e.,

(1) in lieu of an outer marker

(2) improved safety

(3) reduced localizer minima

(4) averted missed approach

(5) expedited departure

are described in the following paragraphs by means of illustrative examples. To facilitate an understanding of the procedures, extensive use is made of charts to reflect but not absolutely duplicate portions of the computer program used by FAA Headquarters to determine the benefit/cost (Phase II) for DME's that are identified by the FAA regions (using Phase I criteria described in Section III) as candidates for establishment with ILS or localizer.

The examples illustrated in this section use average costs and national average weather observations. Since, obviously, weather and costs can differ greatly among airports, their purpose is solely to illustrate the techniques used in the calculation of the benefits associated with each of the above categories. Benefit computations using airport-specific weather and cost data will be done by FAA Headquarters (ASP-220) as part of the Phase II candidate screening process.

7.1 Example of DME in Lieu of Outer Marker Benefit Computation

Step 1: Runway/airport input data.

Runway AIA's

Air Carrier	607
Air Taxi	27
General Aviation	327
Military	0
Total	961

15-year discounted cost for outer marker (OM)		$500,000[a]
ILS without OM 15-year discounted cost.		747,000[b]
DME 15-year discounted cost		167,248
ILS 15-year discounted benefits:	Air carrier	862,207
	Air taxi.	37,015
	General aviation. . .	113,217
	Military.	0

(a) Illustrative cost only, reflecting substantially greater than nominal cost attributable to atypical installation problems such as over water.

(b) Nominal cost from Reference 4 less $25,000 nominal initial cost of OM.

Step 2: Determine the benefit of an ILS using a DME in lieu of an outer marker. This 15-year discounted benefit is the product of the ILS with an outer marker benefit and the avionics mix factor adjustor (obtained from Table 5.3, summed over all user groups as shown below):

Air carrier	$862,207	x 1.00	=	$862,207
Air taxi.	$ 37,015	x .626	=	23,171
General Aviation.	$113,217	x .407	=	46,079
Military.	-	x .626	=	0
ILS with DME in lieu of outer marker benefit			=	$931,457

Step 3: Determine ILS with DME in lieu of an outer marker benefit/cost ratio.

This 15-year discounted benefit/cost ratio (ILOMBC) is defined by the quotient of the benefit determined in Step 2 and the sum of ILS without outer marker and DME costs, as shown below:

$$\sum_{\text{User Groups}} \frac{\text{ILS Benefit x ILS/DME Avionics Mix Factor Adjustor}}{\text{ILS Cost + DME Cost}}$$

Air Carrier: $\frac{862,207 \times 1}{747,000 + 167,248}$ = 0.943

Air Taxi: $\frac{37,015 \times .626}{747,000 + 167,248}$ = 0.026

General Aviation: $\frac{113,217 \times .407}{747,000 + 167,248}$ = 0.050

Total 1.019

By comparison, the example ILS without DME but with an outer marker has a benefit/cost ratio of:

ILS with Outer Marker Benefit/Cost Ratio $\frac{862,207 + 37,015 + 113,217}{747,000 + 500,000}$ = 0.812

Step 4: Outer marker cost threshold.

In the event it is not practical to determine the 15-year discounted cost of an outer marker (which, for example, may have to be sited over water), then the fallback position is to determine the outer marker cost threshold, above which it becomes advantageous to use a DME in lieu of an outer marker. This threshold cost may be determined through the use of the following relationship:

$$\frac{\text{ILS Benefit}}{\text{ILS Cost + O\&M Cost}} = \frac{\text{ILS/DME Benefit}}{\text{ILS Cost + DME Cost}}$$

This relationship essentially causes the ILS and ILS/DME benefit/cost ratios to be equivalent. Solving for the outer marker threshold cost (OMTC) yields:

$$\text{OMTC} = \frac{(\text{ILS Cost + DME Cost}) \times (\text{ILS Benefit})}{\text{ILS/DME Benefit}} - (\text{ILS Cost})$$

In this example:

$$\text{OMTC} = \frac{(747{,}000 + 167{,}248) \times (1{,}012{,}439)}{931{,}457} - (747{,}000)$$

$$= \$246{,}203$$

If the outer marker 15-year discounted costs are determined to be this value or presumably higher, it then becomes advantageous to install the DME in lieu of outer marker.

7.2 Example of Safety Benefit Computation

This benefit computation is applicable only to airports with full ILS. All user groups except military enjoy a DME benefit.

Example: Reno, Nevada, Reno International Airport, Runway 16, Medium Hub

Step 1: Runway/airport input data.

User Group	AIA's on This Runway
Air Taxi	44
General Aviation	298
Air Carrier	354

Step 2: Obtain DME safety benefit factors (derivation described in Section 5.2) from Table 7.1.

User Group	DME Safety Benefit Factor
Air Taxi	$ 13.802/AIA
General Aviation	$ 2.630/AIA
Air Carrier	$643.249/AIA

Step 3: Determine safety benefits as the product of annual instrument approaches and the safety benefit factor.

User Group	DME Safety Benefit Factor
Air Taxi.	44 x 13.802 = $ 607.29
General Aviation.	298 x 2.630 = 783.66
Air Carrier	354 x 643.246 = 227,709.04
Total	$229,099.99

TABLE 7.1

DME at ILS Safety Benefit Factors

User Group	Safety Benefit Factor* ($/AIA)
Air carrier - large hub	881.014
Air carrier - medium hub	643.246
Air carrier - small hub	512.812
Air carrier - non-hub	378.761
General aviation	2.630
Air taxi	13.802
Military	N/A**

* Derived in Section 5.2.

** Military accident statistics at civil airports are virtually non-existent. Therefore, no safety benefit due to the addition of DME could be ascertained for this category of user. Since military operations at civil airports are rare, it was believed that the impact of this lack of information would be extremely small.

7.3 Example of Reduced Localizer Minima Benefit Computation

Example: Carlsbad, California, Palomar Airport, Runway 24, Air Carrier User Group (largest aircraft category consistently using the runway)

Step 1: Runway/airport input data.

	Assumed User Group	Ceiling (feet)	Visibility (nmi)
Localizer Minima:			
Aircraft Category D.	AC	737	2
Estimated Minima for Proposed Localizer/DME:			
Aircraft Category D.	AC	400	3/4

Weather Condition (National Average):*	% Total Observation
(a) (1,500 and/or 3) > C/V $\geq$ 400-1.	10.75
(b) (400 and/or 1) > C/V $\geq$ 200-1/2.	1.61
(c) (200 and/or 1/2) > C/V $\geq$ 100-1/4 (d) (100 and/or 1/4) > C/V	1.12
Total less than or equal to 1500-3	13.48

Runway AIA's:

User Group:	AIA's
Air Carrier	11
Hub Size.	Medium

* If benefit computation using airport-specific weather is desired, contact ASP-220.

The benefit associated with reducing the published localizer minima through the addition of a DME is related to the number of AIA's, the magnitude of the minima reduction made possible by the DME, and the distribution of IFR weather conditions at the airport of interest. These weather conditions are described as percent of total observations between ceiling/visibility limits of 1500-3 and 400-1; 400-1 and 200-1/2; 200-1/2 and 100-1/4; and less than 100-1/4. In this example, as shown in Step 1, these values are 10.75, 1.61, and 1.12 percent, respectively.

If the localizer and the localizer/DME minima happen to coincide with the ceiling/visibility values used as limits to describe the weather conditions, i.e., 1500-3, 400-1, 200-1/2, and/or 100-1/4, the percent increase in IFR operations (assumed to be directly related to percent observations) attributable to the addition of a DME could be easily determined. However, for the general case, when those minima are different from the weather condition limits, a linear interpolation procedure can be used.

Step 2: Determine percent increase in total IFR weather conditions due to lower minima (see Table 7.2).

Air carrier . . . . . . LOC Minima. 700-2

Air carrier . . . . . . LOC/DME Minima. . . . . . 400-3/4 (proposed)

$$\text{PC IFR} = \frac{(\text{PC LOC MIN}) - (\text{PC LOC/DME})}{(\text{PC 1500-3}) - (\text{PC LOC MIN})}$$

where:

PC IFR = percent increase in acceptable IFR weather

PC LOC MIN = percent observations less than or equal to localizer minima (Table 7.2)

PC LOC/DME = percent observations less than or equal to localizer/DME minima (Table 7.2)

PC 1500-3 = percent observations less than or equal to 1500-3 (Table 7.2)

$$\text{PC IFR} = \frac{6.59 - 2.37}{13.48 - 6.59} = \frac{4.22}{6.89}$$

$$= .612\ (61.2\%)$$

TABLE 7.2

Percentage Distributions of Weather Observations
Equal to or Less Than Selected Ceilings
and/or Visibilities
(National Average)

Ceiling (Feet)	Visibility (Miles) 1/2 %	3/4 %	1 %	1-1/2 %	3 %
200	1.12	1.52	2.01	3.13	7.10
300	1.48	1.79	2.21	3.25	7.13
400	2.14	2.37	2.73	3.64	7.29
500	2.88	3.08	3.38	4.20	7.60
600	3.67	3.84	4.09	4.81	7.99
700	4.57	4.72	4.95	5.60	8.57
800	5.47	5.61	5.81	6.40	9.15
1,000	7.24	7.36	7.54	8.05	10.48
1,500	10.80	10.91	11.05	11.45	13.48

Step 3: Determine percent AIA's using localizer/DME.

Identify, from Table 5.2, percent of air carrier (Category D aircraft) AIA's at non-ILS airport (Palomar) that would use localizer/DME approach (balance assumed to use localizer approach).

Step 4: Determine additional AIA's resulting from DME installation.

AIA's is the product of current AIA's (from Step 1), percent increase in acceptable IFR weather, i.e., $\geq$ localizer/DME minima (from Step 2), and the LOC/DME utilization factor from Step 3.

$$\text{AIA's} \times \text{PC IFR} \times \text{L/D UF} = \Delta\text{AIA}$$

$$11 \times 0.612 \times 1.0 = 6.73$$

Step 5: Determine 15-year discounted benefit.

Benefit is equal to the product of the number of additional AIA's from Step 4 (assumed to be equal to the number of annual averted flight disruptions) and the 15-year discounted benefit per averted flight disruption from Table 5.10.

$$6.73 \times \$31{,}173 = \$209{,}857$$

To determine the total benefit for lower minima over all user groups, substitute the applicable use factor from Table 5.2, the AIA's from Step 1, and the benefits per averted flight disruption from Table 5.10 into Steps 3 to 5 above for each other user group and sum the benefits calculated for each user group.

7.4 Example of DME with Localizer Averted Missed Approach Benefit

Example: Reno, Nevada, Reno International Airport, Runway 34, Air Carrier User Group (largest aircraft category consistently using runway)

Step 1: Runway/airport input data.

	Assumed User Group	Ceiling (feet)	Visibility (nmi)
Localizer Minima:			
Aircraft Category D.	AC	1,388	2.00
Localizer/DME Minima:			
Aircraft Category D.	AC	928	2.00

Weather Condition (National Average):*	% Total Observations
(A) (1,500 and/or 3) > C/V $\geq$ 400-1	10.75
(B) (400 and/or 1) > C/V $\geq$ 200-1/2	1.61
(C) (200 and/or 1/2) > C/V $\geq$ 100-1/4 (d) (100 and/or 1/4) > C/V	1.12
Total less than or equal to 1500-3.	13.48

Runway AIA's: (by user group):

User Group:	AIA's
General Aviation.	128
Air Taxi.	19
Air Carrier	152
Military.	10

Average Averted Missed Approach Go-Around Distance in nmi (nominally set at 40.05 nmi unless overridden by regional input). . . . . . . 40.05 nmi

*If benefit computation using airport-specific weather is desired, contact ASP-220.

Step 2: Determine applicable weather conditions.

These conditions lie between the localizer minima and the nominal VFR condition at 1500-3 and, for this example, are approximated by Conditions A-I, A-II, and A-III. See Figure 7.2.

Step 3: Determine probability of occurrence for each weather condition.

From Step 1, the probability of weather Condition A is 0.1075 (10.75 percent). The weather weighting factors of Figure 7.1 are applied to this value, producing the appropriate weather probability of occurrence for each weather condition:

Weather Condition	Probability of Occurrence Entire Condition A	x	Weighting Factor	x	Probability of Occurrence
A-I	0.1075	x	0.188	=	0.02096
A-II	0.1075	x	0.0372	=	0.003999
A-III	0.1075	x	0.2790	=	0.029992

Step 4: **Determine difference between applicable weather conditions and the localizer/DME minima, i.e., ΔC and ΔV.**

Localizer/DME minima of 928-2 is obtained from Step 1. Ceiling/visibility values representing the applicable weather conditions are obtained from Figure 7.2.

Weather Condition	{- Localizer/ DME Minima}	+	{Representative Ceiling-Visibility}	ΔC/ΔV
A-I	(-C = 928)	+	(C = 1,500)	574-1/4
	(-V = 2)	+	(V = 2-1/4)	
A-II	(-C = 928)	+	(C = 1,250)	322-1/4
	(-V = 2	+	(V = 2-1/4)	
A-III	(-C = 928)	+	(C = 1,250)	322-1
	(-V = 2)	+	(V = 3)	

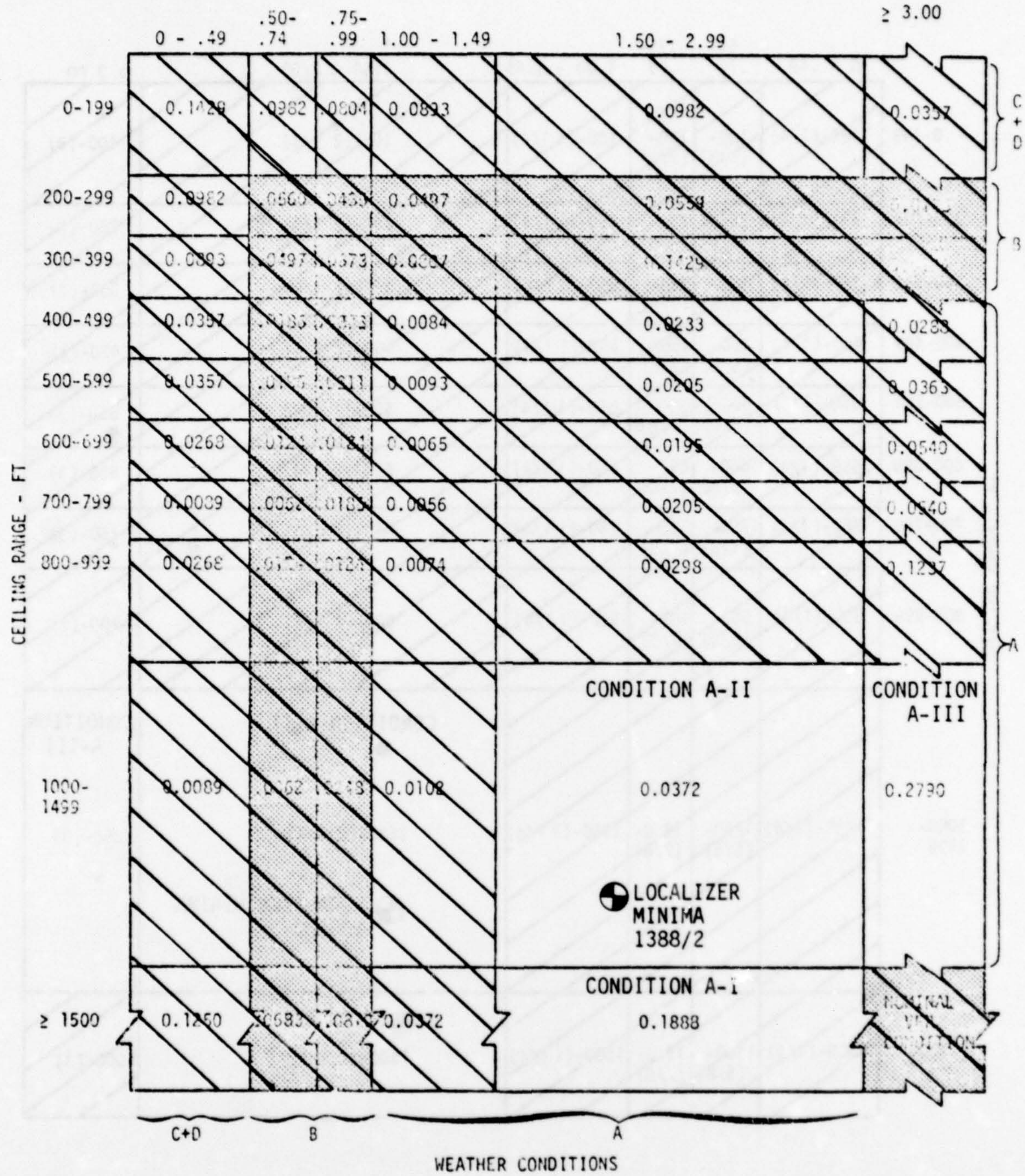

Figure 7.1 Example of the Use of Weather Weighting Factors Visibility Range (nmi)

CEILING RANGE - FT	0 - .49	.50-.74	.75-.99	1.00 - 1.49	1.50 - 2.99	≥ 3.00
0-199	100-(1/4)	100-(5/8)	100-(7/8)	100-(1 1/4)	100-(2 1/4)	100-(3)
200-299	250-(1/4)	250-(5/8)	250-(7/8)	250-(1 1/4)	250-(2 1/4)	250-(3)
300-399	350-(1/4)	350-(5/8)	350-(7/8)	350-(1 1/4)	350-(2 1/4)	350-(3)
400-499	450-(1/4)	450-(5/8)	450-(7/8)	450-(1 1/4)	450-(2 1/4)	450-(3)
500-599	550-(1/4)	550-(5/8)	550-(7/8)	550-(1 1/4)	550-(2 1/4)	550-(3)
600-699	650-(1/4)	650-(5/8)	650-(7/8)	650-(1 1/4)	650-(2 1/4)	650-(3)
700-799	750-(1/4)	750-(5/8)	750-(7/8)	750-(1 1/4)	750-(2 1/4)	750-(3)
800-999	900-(1/4)	900-(5/8)	900-(7/8)	900-(1 1/4)	900-(2 1/4)	900-(3)
1000-1499	1250-(1/4)	1250-(5/8)	1250-(7/8)	1250-(1 1/4)	CONDITION A-II 1250-(2 1/4) LOCALIZER MINIMA 1388/2	CONDITION A-III 1250-(3)
≥ 1500	1500-(1/4)	1500-(5/8)	1500-(7/8)	1500-(1 1/4)	CONDITION A-I 1500-(2 1/4)	1500-(3)

Figure 7.2 Example of the Use of Representative Ceiling (feet)/ Visibility (nmi) Value Factors

Step 5: Determine probability of an averted missed approach when the prevailing weather conditions are within the range of each applicable weather condition.

Use Figure 7.3 with the appropriate $\Delta V/\Delta C$ from Step 4 and the localizer/DME ceiling of 928 feet from Step 1.

Weather Condition	Probability of Averted Missed Approach During Stipulated Weather Condition
A-I	0.032
A-II	0.045
A-III	0.026

Step 6: Determine probability of an averted missed approach.

This step is accomplished by taking the sum of the products of the probability of an averted missed approach under specified weather conditions (Step 5) and the probability of that weather condition occurring (Step 3), across all applicable weather conditions:

Weather Condition	Probability of Averted Missed Approach under Specified Weather Condition	x	Probability of Specified Weather Condition Occurring	=	Probability of an Averted Missed Approach per AIA
A-I	0.032	x	0.020296	=	0.00064947
A-II	0.045	x	0.003999	=	0.00017995
A-III	0.026	x	0.029992	=	0.00077979
				Total	0.0016092

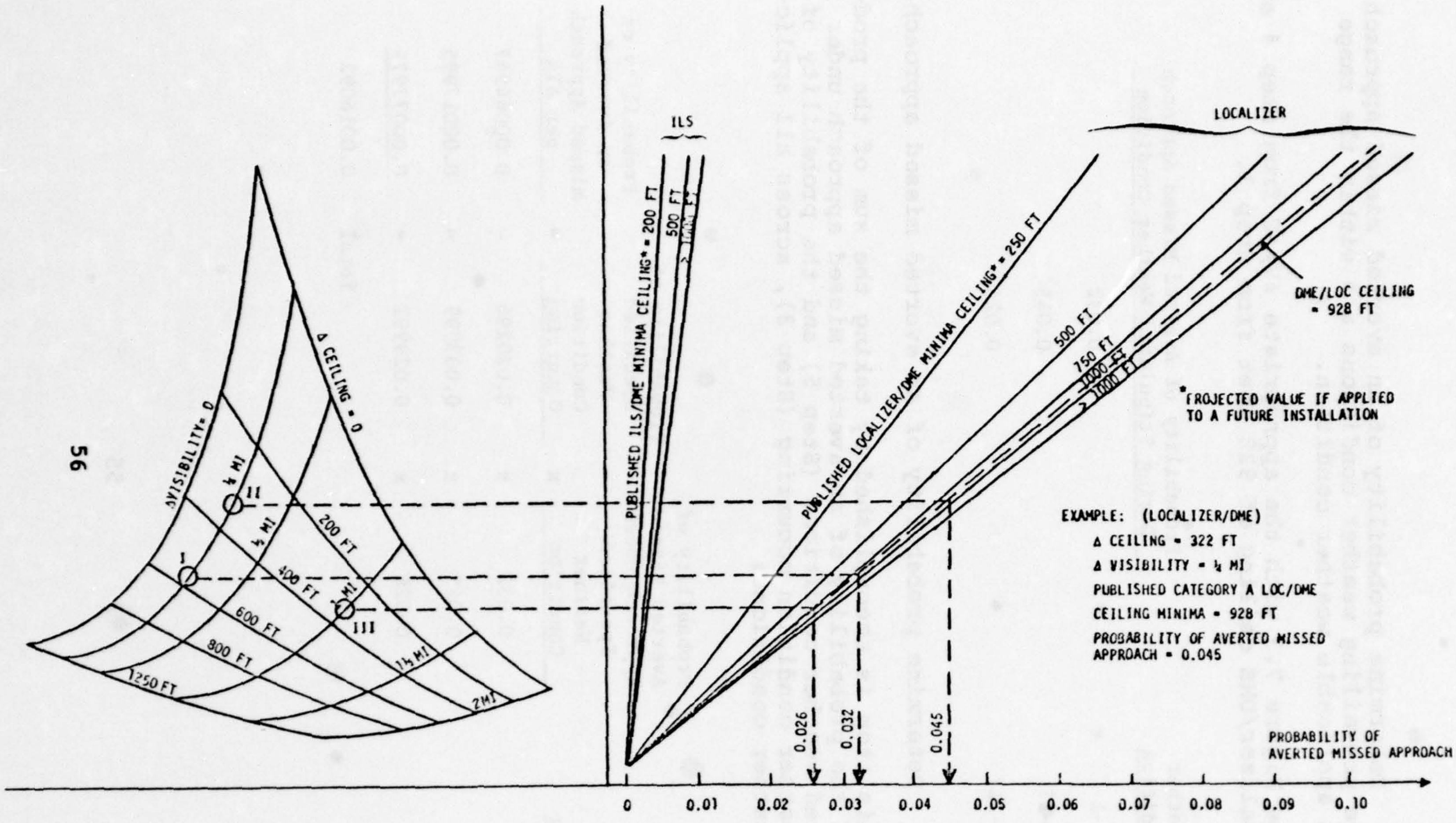

Figure 7.3 Probability of Averted Missed Approach Due to DME Opportunity

Step 7: Determine the 15-year discounted averted missed approach benefit at Reno International, Runway 34 for air carriers.

This benefit is the product of the probability of an averted missed approach per AIA (Step 6), the number of air carrier AIA's (Step 1), percent of instrumented fleet equipped with DME from Table 5.2, the appropriate dollar benefit per averted missed approach taken from Table 5.11, and the appropriate 15-year discount factor taken from Table 5.5, adjusted by the go-around distance obtained from Step 1.

$$0.0016092 \times 152 \times 1.00 \times 194.24 \times 9.513 \times \frac{40.05^{a}}{40.05^{b}} = \$451.97$$

a. Obtained from Step 1.

b. Constant (average go-around distance).

As in the calculation of reduced localizer minima benefits (Section 7.3), this process would be repeated using the probability of an averted missed approach from Step 6 and the appropriate AIA's (Step 1), avionics mix factor (Table 5.2), dollar benefit per averted missed approach (Table 5.11), and discount factor (Table 5.5) for each other user group summed to produce the total 15-year discounted averted missed approach benefit.

7.5 Example of Expedited Departure Benefit Computation

Example: San Jose, California, San Jose Municipal Airport, Runway 30L, General Aviation User Group

Step 1: Runway/airport input data.

Runway AIA's:

User Group:	AIA's
Air Carrier	2,449
Air Taxi	422
General Aviation	2,276
Military	9

Reduction in departure flight path due to addition of DME-supported departure procedures:

Assumed as an example = 2 nmi

Step 2:

Using the appropriate user group expedited departure value from Table 5.12, form the product with this value and the user group runway AIA's. This product yields the benefit dollar per nautical mile saved in the reduced departure flight path. Final multiplication of this quantity with the departure path reduction yields the total 15-year discounted benefit. Hence,

Air Carrier:	46.13 x 2,449 x 2	=	$225,945
Air Taxi:	15.70 x 442 x 2	=	13,251
General Aviation:	2.95 x 2,276 x 2	=	13,428
Military:	3.46 x 9 x 2	=	62
	Total	=	$252,686

The values in Table 5.12 are determined as follows: Aircraft operating costs from ASP-220 are given as $970/block hour, $360/block hour, and $90/block hour for air carrier, air taxi, and general aviation, respectively. Under the assumption that military and general aviation are to be equivalent implies a military aircraft operating cost of $90/block hour. Another component of the expedited departure is aircraft speed in the departure phase. These speeds were estimated to be (average values) 200 knots for air carrier, 140 knots for air taxi, and 110 knots for general aviation. These values were derived in concurrence with the Flight Standards Service. Again, under the study ground rules, the military aircraft speed is also taken as 110 knots (equivalent to general aviation). The avionics mix factor relating to "Localizer only" of Table 5.2 is utilized since the DME-supported departure path is utilized for all DME-equipped aircraft regardless of whether or not it has both LOC and glide slope. The avionics mix factor together with the other components are combined in the following manner to derive the values displayed in Table 5.12.

$$\text{Table 5.12 Value} = \frac{\text{Aircraft Operating Cost x Discount Factor x Avionics Mix}}{\text{Aircraft Speed}}$$

Hence,

Air Carrier: $\frac{970 \times 9.513 \times 1}{200} = 46.13$

Air Taxi: $\frac{360 \times 10.949 \times 0.5575}{140} = 15.70$

General Aviation: $\frac{90 \times 14.052 \times 0.2571}{110} = 2.95$

Military: $\frac{90 \times 7.605 \times 0.5575}{110} = 3.46$

These values are benefit dollars per nautical mile flight path reduction per AIA. An additional assumption is that for each AIA there is an instrument departure. Therefore, the recorded AIA's are a good measure of the number of instrument departures to be expected at a particular airport.

7.6 Benefit/Cost Ratio

7.6.1 Without Using DME in Lieu of an Outer Marker

Step 1: The benefits computed for improved safety, reduced localizer minima, averted missed approach, and expedited departure as described in Sections 7.2 to 7.5 should be summed over all appropriate user groups, resulting in the total 15-year discounted benefit expected should a DME be established with either an ILS or localizer approach aid (as appropriate for the candidate runway).

Step 2: Compute 15-year discounted DME cost from the region inputs (illustrative example different from nominal values of Section IV).

Equipment	$48,400
Installation	$16,000
Annual O&M	$15,000

Compute 15-year discounted present value cost.

DME PVC = Equipment Cost + Installation Cost + (7.605) Annual O&M Cost

= $48,400 + $16,000 + (7.605)($15,000)

= $178,475

Step 3: Compute the benefit/cost ratio by dividing the total benefits of Step 1 by the costs of Step 2.

7.6.2 When DME Is Used in Lieu of an Outer Marker with an ILS

Step 1: Determine the combined ILS plus DME 15-year discounted benefits.

Add the benefit derived in Step 1 of Section 7.6.1 to the ILS/DME benefit determined in Step 2 of Section 7.1.

Step 2: Determine the 15-year discounted benefit/cost ratio for the combined ILS-DME system.

Take the total benefits determined in Step 1 and divide that value by the combined ILS (without outer marker) plus DME cost, obtained from Step 1 of Section 7.1.

REFERENCES

1. "Airway Planning Standard Number One - Terminal Air Navigation Facilities and Air Traffic Control Services," Order 7031.2B, dated September 20, 1974.

2. "United States Standard for Terminal Procedures," (TERPS Third Edition), July 1976, FAA.

3. "FAA Air Traffic Activity, Calendar Year 1976," dated December 31, 1976.

4. "Establishment Criteria for Category I Instrument Landing System (ILS)," Report No. ASP-75-1, dated December 1975.

5. "Airman's Information Manual," 1975.

6. Draft copy of "Establishment Criteria for Category I Microwave Landing Systems (MLS)," Report No. FAA-ASP-78-1, dated August 1978.

7. "Airport Activity Statistics of Certificated Route Air Carriers," 12 Months Ended December 31, 1976, FAA/CAB.

8. 1976 FAA Airport Directory Tapes.

9. "Ceiling-Visibility Climatological Study and Systems Enhancement Factors," Contract No. DOT-FA75WAI-547, dated June 1975.

10. "Jeppessen Approach Charts," Revision 20, Vol. 4, Jeppessen Sanderson, Inc., July 1977.

11. "Flight Procedures and Airspace," Order 8260.19, Change 13, dated September 1975.

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